

Laser heart surgery gets
boost from chemistry
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Petrochemical Feedstocks

Gas liquids stay surprisingly
strong Page 17

News of the Week

■ If Socal acquisition of Gulf goes through, new company will be U.S.'s third largest chemical-producing oil firm. **Page 4**

■ EPA proposes to hasten the phaseout of lead in gasoline to late 1980s. **Page 5**

■ Ethylene dibromide limits on fruit set by EPA. **Page 5**

■ OSHA head Thorne Auchter steps down. **Page 6**

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Business

Major U.S. pharmaceutical companies thrived in 1983, especially on human health care products; Searle was big winner. **Page 8**

Government

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National Research Council study confirms difficulty of assessing commercial chemicals' potential hazard to health due to lack of toxicity testing information, data on human exposure. **Page 12**

Science

Joint effort of chemistry professor and physicians produces argon laser technique to treat congenital heart defect. **Page 14**

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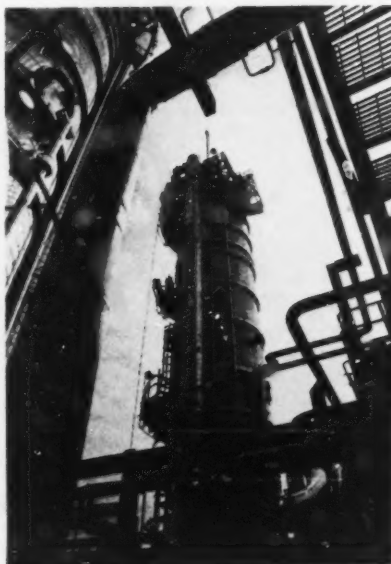
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Petrochemical Report

Although gas liquids are still strong as feedstocks for U.S. petrochemicals, smart producers are geared up to switch easily to other raw materials. **Page 17**

SOCAL TO ACQUIRE GULF: Deal will create broad chemicals line

A new entry in the top 10 U.S. chemical producers is in the making. Under an agreement reached last week, Standard Oil of California will acquire Gulf Corp. for \$13.3 billion, or \$50 per share. The deal represents the biggest corporate merger in U.S. history, topping the record \$10.1 billion that Texaco paid for Getty Oil in January. The purchase, which will make Socal the third largest U.S. oil company and the third largest chemical-producing oil company, is still subject to approval by government antitrust authorities.

The combination of the two corporations' chemical operations will create a broad chemical product line ranging from basic chemicals and fertilizer raw materials to catalysts and electronic chemicals. It will include Socal's Chevron Chemical subsidiary, which along with other Socal chemical units lost \$12 million in 1983 (but had net income of \$3 million in the fourth quarter); Gulf's Gulf Oil Chemicals subsidiary, heavy in petrochemicals; and Gulf's joint venture with Kaiser Aluminum & Chemical, the Harshaw/Filtrol partnership (managed by Kaiser's Filtrol subsidiary). Gulf's chemical units lost \$76 million in 1983 (including a loss of \$69 million in the fourth quarter).

Combined, the Socal and Gulf chemical operations would rank high among U.S. chemical producers. In C&EN's ranking of the Top 50 producers, Socal is now 16th and Gulf 33rd. Together, they would be tied for seventh with Celanese, just below sixth-place Shell Oil at sales of just over \$3 billion (1982).

Further, the combined chemical enterprise would have little overlap in product lines. Gulf's petrochemicals and specialties are mostly different from Chevron's agricultural and other products.

Socal at a glance

Sales: Full-year 1983—\$29.2 billion, down 19% from 1982; fourth-quarter 1983—\$7.4 billion, down 6%. Chemical sales 1982—\$1.05 billion (3%)

Earnings: Full-year 1983—\$1.6 billion, up 15% from 1982; fourth-quarter 1983—\$403 million, down 5%. Chemical earnings 1983—loss of \$12 million; fourth-quarter 1983—profit of \$3 million

Major chemical products (Chevron Chemical subsidiary): Alkylphenols, agricultural and household pesticides, ammonium nitrate, ammonium phosphates, nitric acid, nitrogen solutions, lubricating oil, hydrogen, sulfur, sulfuric acid, alpha-olefins, polybutenes, alkylbenzene, uranium oxide

Chemical sales rank: 33rd

Gulf Oil at a glance

Sales: Full-year 1983—\$28.9 billion, down 6% from 1982; fourth-quarter 1983—\$7.5 billion, down 8%. Chemical sales 1982—\$2.01 billion (7%)

Earnings: Full-year 1983—\$831 million, up 8% from 1982; fourth-quarter 1983—\$229 million, up 24%. Chemical earnings 1983—loss of \$76 million, compared to a loss of \$329 million in 1982; fourth-quarter 1983—loss of \$69 million, compared to loss of \$74 million in 1982

Major chemical products: Benzene, toluene, xylene, sulfur, cyclohexane, cumene, ethylbenzene, styrene, ethylene, propylene, urea-formaldehyde and phenol-formaldehyde resins, polyethylene, polypropylene, catalysts, pigments, electronic and specialty industrial chemicals (the last three by joint venture with Kaiser Aluminum & Chemical)

Chemical sales rank: 16th

To win Gulf, Socal had to beat out three other suitors—Atlantic Richfield Corp., Kohlberg, Kravis, Roberts & Co., an investment firm that tried to arrange a leveraged buyout; and Mesa Petroleum, which, under the leadership of its chairman, T. Boone Pickens Jr., had been maneuvering for a "hostile" takeover since last August.

The highest bid for Gulf—\$87.50 per share—came from Kohlberg, Kravis, Roberts & Co., but Gulf turned it down because the payment would have been only partially in cash, and financing would have taken several months to arrange. Atlantic Richfield, which is reported to have established a large line of credit with banks, tendered the lowest bid—\$72 per share. Gulf rejected that as inadequate.

Atlantic Richfield, considered Socal's most serious competition, reacted tersely to the agreement. "Another competitor's bid was selected, and we wish them and Gulf Oil Corp. well in their endeavors," the company stated.

Completion of the acquisition, however, is not altogether assured. Coming so soon after the giant Texaco-Getty merger, the Socal-Gulf agreement has stirred up a hornet's nest in Congress, where a group of both Senators and Representatives are trying to line up support for legislation that would block such transactions for a variety of reasons, ranging from antitrust to protection of jobs. At this point, it is uncertain whether Congressional action, if it were to come about, would come in time to stop the Socal-Gulf merger or might only block similar oil company mergers in the future. The Federal Trade Commission will have to approve the Socal-Gulf deal and could demand certain divestments to satisfy antitrust requirements. Fi-

nal action could take at least a month.

At the end of the week, Socal pledged to shed any Gulf assets except for oil and gas exploration and production properties to win antitrust clearance. Socal's chief reason for buying Gulf is to increase its oil and gas reserves. The antitrust debate has focused on the large number of gasoline stations the combined company would own.

The reaction in Washington was enough to scare off arbitrageurs and other investors hoping to profit from Socal's tender offer. For example, Gulf stock was the most active issue on the New York Stock Exchange last Thursday, but closed at \$64.75 per share, down \$4.50 for the day, and more than \$15 below Socal's offer. Ordinarily, the stock price of a company about to be acquired rises to more or less the level of the tender offer.

If the government were to block the acquisition by Socal, the Kohlberg, Kravis offer might look more attractive to Gulf. Not only would a leveraged buyout by the investment firm soothe antitrust officials, it probably also would soothe Gulf management, which probably would suffer fewer alterations.

Socal has not discussed publicly its plans for Gulf's extensive chemi-

Top 10 chemical-producing oil companies

\$ Billions	1982 chemical sales
Exxon	\$7.26
Shell Oil	3.09
Socal-Gulf	3.05
Standard Oil (Ind.)	2.79
Phillips Petroleum	2.36
Atlantic Richfield	2.24
Mobil	2.15
Texaco-Getty Oil	1.69
Occidental Petroleum	1.26 ^a
Ashland Oil	1.20

^a Does not include all chemicals.

cal operations, which have lost money consistently. Last year, Gulf tried to divest its unprofitable Harshaw Chemical subsidiary but had to settle for the partnership with Kaiser Aluminum & Chemical. Socal's Chevron unit has also performed poorly in recent years.

The uproar in Congress adds an element of doubt to speculations about other future mergers of large oil companies. However, the merger trend is expected to continue; oil analysts note that it is easier now to find oil reserves on the floor of the New York Stock Exchange than under the Arctic ice cap. □

sure and neuropsychologic deficits in children." Ethyl is a major manufacturer of lead antiknock agents.

According to Gregory Dana, another policy analyst in the mobile sources office, EPA has yet to assess the impact of a stricter lead-in-gasoline rule on small refiners. The agency also has not calculated what savings will accrue to car owners through the use of reduced- or no-lead gasoline, although it says maintenance and repair costs should be lower. Another health benefit would be the elimination of the carcinogen ethylene dibromide, now added to leaded gasoline.

Ruckelshaus says a proposal could be announced as early as April, but some staffers peg the announcement date closer to June. □

Ethylene dibromide level on fruit limited

Environmental Protection Agency Administrator William D. Ruckelshaus has made the expected decision limiting the amount of ethylene dibromide on citrus and tropical fruit to 30 ppb. The standard goes into effect in 30 days, but will affect only about 2% of the fruit sold in the U.S.

This most recent action caps the agency's offensive against EDB, which began in September 1983 with the banning of the pesticide's use as a soil fumigant. All foods now have residue standards for EDB, and all U.S. uses of the chemical on food as a pesticide or fumigant have been cut off. Ruckelshaus did not put an immediate ban on the use of EDB as a fruit fumigant, because fruit packers and shippers already have stopped using it on fruit targeted for U.S. markets. EPA still plans to ban EDB's use on fruit completely in September. Some EDB use is still allowed on products intended for exports.

Only fruit traveling to Texas, New Mexico, California, Florida, or Hawaii has to be fumigated in the U.S., and methyl bromide has been substituted for EDB in almost all cases. A gas, methyl bromide doesn't appear to stick to food as EDB does. Residues of methyl bromide on fruit

EPA plans to speed up phaseout of leaded gas

The Environmental Protection Agency is drafting proposals to speed up the phaseout of leaded gasoline, according to the agency's Administrator, William D. Ruckelshaus. If history is any guide, the proposals are likely to encounter stiff opposition from some gasoline refiners.

The current limit of 1.1 g of lead per gal of gasoline, which went into effect in 1982, took EPA eight months to establish. It calls for a phaseout of all leaded gasoline by 1990. The stricter proposals now being drafted would further restrict or ban lead use as a gasoline additive by the late 1980s.

The agency's current action apparently was catalyzed by health studies that confirm lead is a toxic air pollutant, and by recent evidence of widespread, illegal use of leaded

gasoline in vehicles designed to run only on unleaded fuel. According to Barry D. Nussbaum, a policy analyst in EPA's mobile sources office, about 23% of all car owners in 1982 either had tampered with such things as catalytic converters or improperly switched to leaded gasoline.

Agency officials say studies indicate severe health risks from lead exposure, especially neurological damage, to children in inner-city areas. On the other hand, Ethyl Corp. vice chairman Lawrence E. Blanchard Jr. says there is "no sound evidence linking lead in gasoline and lowering of IQ in children." He claims an EPA-commissioned study last year found no studies that "have validly established a relationship between low-level lead expo-

Drug Profits Up Solidly in 1983

Most major pharmaceutical houses parlayed strong growth in their human health product lines and general improvement in other, more cyclical, product segments like chemicals to strong sales and earnings gains in the final quarter of 1983 and for the year as a whole. Revenues would have increased even more had not the companies, most of which do a very large share of their business overseas, been hurt by the strength of the U.S. dollar against foreign currencies. Profit margins remained traditionally robust.

A group of 14 of the largest drug firms recorded an overall sales gain of 8% in the fourth quarter and 6% for 1983. Net income rose even more: 14% for the final quarter and 13% for the entire year. The profit margin (after-tax earnings as a percentage of sales) for the group averaged 11.1% in the fourth quarter, compared to 10.5% a year earlier, and 11.2% for the year, compared to 10.5% in 1982.

The impact of the dollar's might on income was deep, a function of most pharmaceutical houses' broad foreign exposure. Pfizer, for in-

stance, recorded some 57% of its 1981 sales abroad. The estimated overseas share that year for Merck was 47%, Bristol-Myers 29%, Warner-Lambert 45%, Eli Lilly 38%, Abbott Laboratories 35%, and Upjohn 38%.

As a result, Pfizer, for one, reports that worldwide sales in 1983, which rose 7% on a dollar basis, actually rose 11% on a local currency basis. Bristol-Myers chairman Richard L. Gelb points out that the company's U.S. sales rose 13%, but international sales increased only slightly because of exchange rates. Sales were reduced \$229 million, or 6%, as a result, he says. At Warner-Lambert, chief executive Ward S. Hagan says international sales declined 5% in dollars. Excluding exchange rate changes, he says, they would have risen 5%.

Net income growth also was restrained, in some cases, by increases in the effective income tax rate. At Upjohn, for example, the effective tax rate rose from 24.5% in 1982 to 30.0% last year, accounting for a \$12 million reduction in earnings. Upjohn says the higher rate is attributable mostly to the company's having a smaller propor-

tion of total earnings from its tax-exempt Puerto Rican operations than the year before. Merck's effective tax rate expanded to 37% in 1983 from 31% in 1982, and G. D. Searle's tax rate rose about 5% from 1982 to 1983.

Despite generally strong performance by drug product lines, the most spectacular sales gains by a pharmaceutical company came from a nondrug product—the artificial sweetener aspartame. Searle's sales shot up 33% in the fourth quarter and 30% for all of 1983 because of aspartame. The firm's sales of the sweetener totaled \$336 million in 1983—or 36% of all sales—compared to \$74 million—or 10%—in 1982.

In the fourth quarter, no other major pharmaceutical firm came close to Searle's sales increase. The next highest were Pfizer, Abbott Labs, and A. H. Robins, with increases of 12%, 11%, and 11%, respectively. But other companies made bigger improvements in earnings. Warner-Lambert's net income rose 62%, Upjohn's rose 37%, and Pfizer's rose 28% from the year-earlier period.

David Webber, New York

Major drug firms had a 14% increase in earnings in the fourth quarter

Company	FOURTH-QUARTER 1983						FULL-YEAR 1983					
	Sales	Earnings ^a	Change from 1982		Profit margin ^b		Sales	Earnings ^a	Change from 1982		Profit margin ^b	
	(\$ millions)		Sales	Earnings	1983	1982	(\$ millions)		Sales	Earnings	1983	1982
Abbott Laboratories	\$802.0	\$106.1	11%	21%	13.2%	12.2%	\$2927.9	\$347.6	13%	20%	11.9%	11.1%
Becton Dickinson	256.2	11.0	7	-16	4.3	5.5	1119.8	29.3	3	-58	2.6	6.4
Bristol-Myers	955.7	103.8	7	17	10.9	9.9	3917.0	408.0	9	17	10.4	9.7
Eli Lilly	753.1	115.4	5	16	15.3	13.8	3033.7	457.4	2	11	15.1	13.9
Merck	855.8	104.8	8	5	12.2	12.6	3246.1	450.9	6	9	13.9	13.6
Pfizer	972.9	119.2	12	28	12.3	10.7	3750.0	447.1	7	33	11.9	9.5
A. H. Robins	145.4	16.9	11	6	11.6	12.2	563.5	67.9	17	30	12.0	10.9
Schering-Plough	434.5	36.2	10	2	8.3	9.0	1808.5	178.5	5	0	9.9	10.3
G. D. Searle	284.4	43.6	33	4	15.3	19.5	946.0	149.1	30	15	15.8	17.8
SmithKline Beckman	717.5	117.4	4	-2	16.4	17.3	2835.4	486.0	7	7	17.1	17.2
Squibb	477.2	43.3	4	19	9.1	8.0	1768.9	173.3	7	13	9.8	9.2
Sterling Drug	480.6	35.5	7	12	7.4	7.1	1901.2	136.8	6	4	7.2	7.3
Upjohn	505.3	33.8	9	37	6.7	5.3	1986.1	160.2	9	27	8.1	6.9
Warner-Lambert	786.0	48.5	5	62	6.2	4.0	3108.3	200.5	-4	23	6.5	5.0

^a Excludes extraordinary and nonrecurring items. ^b After-tax income as a percentage of sales.

Study confirms paucity of chemical toxicity data

A study by a National Research Council committee has documented conventional wisdom: So little toxicity testing and exposure information is available on tens of thousands of important commercial chemicals that assessing their potential hazard to human health is not now possible.

What the three-year, \$2.2 million report does do is quantify the extent of ignorance and assess the value of existing toxicity data. For the first time the report offers the National Toxicology Program, which commissioned it, "a much better fix on the extent of what is or is not known, and a good fix on the quality of information available," says John C. Bailar, a Harvard University biostatistician and chairman of the committee's panel on sampling.

Bailar says he realized that there was "very substantial ignorance about the toxicity of materials, even for those substances in use, but I didn't expect it to be as great as it turned out to be." Little toxicity information and even less human exposure data are available for the majority of the chemicals the panel scrutinized closely—pesticides, cosmetics, drugs, food additives, and chemicals in commerce listed under the Toxic Substances Control Act—the reports states. That information void makes it difficult, if

not impossible, to assess human health hazards. Even for the more widely tested categories of chemicals, complete health hazard assessments are possible on only 10% of pesticides and inert ingredients of pesticide formulations, and 18% of drugs and inert carrier vehicles.

More important, according to the study, no toxicity information exists for nearly 80% of the chemicals used in commercial products and processes and inventoried under TSCA. However, Garrity Baker, health, safety, and chemical regulations staff executive with the Chemical Manufacturers Association, says "a lot more information is available on toxicity than the study panel had access to." Further, Baker adds, "Health hazard evaluation depends on more than just toxicity data." Other factors that need to be considered are potential for human exposure, the conditions of use, the physical-chemical properties of the chemical, and its structural similarity to other "bad acting" chemicals.

John Doull, a pharmacologist at the University of Kansas Medical Center and cochairman of the committee's panel on toxicity data, acknowledges that the report is "a worst-case analysis." Still, he says, it's a worrisome state of affairs. "As long as we have all those untested compounds, there might be another

thalidomide out there." He is referring to the chemical that caused birth defects in infants in the U.K., but which was never marketed in the U.S.

The report, Doull says, does not answer the question, "Is there a big potential health hazard out there?" That wasn't its charge. What it does do is give the National Toxicology Program (NTP) "some hard data about the magnitude of their task," he says. NTP, an agency within the Department of Health & Human Services, selects and tests potentially toxic chemicals.

The study also offers NTP a four-stage process for setting testing priorities. Though philosophically based, as opposed to cookbook specific, the priority-setting concept "will help us do a better job in selecting chemicals for testing," says David P. Rall, director of the National Institute of Environmental Health Sciences and head of NTP. "It tells us how to use the computerized data bases, how to link into them," Rall explains. Still, Bailar cautions, "Putting the scheme into effect will be a major operation."

Rall says the report offers a "fascinating snapshot look at the chemicals in commerce." That may be its most important contribution. By *Chemical Abstracts* reckonings, there are some 5 million known chemicals. About 53,500 distinct substances (65,725 if duplicates are counted) are regulated or inventoried by the Environmental Protection Agency and the Food & Drug Administration. Not all, not even most, can be tested for toxicity. (Even the academy panel could focus only on a selected list of 675 and eventually on a subset of 100 chemicals for their examination.) "It is very important to know how big the universe of ignorance is to know where to start testing," says Ellen Silbergeld, Environmental Defense Fund toxicologist and consultant to the study.

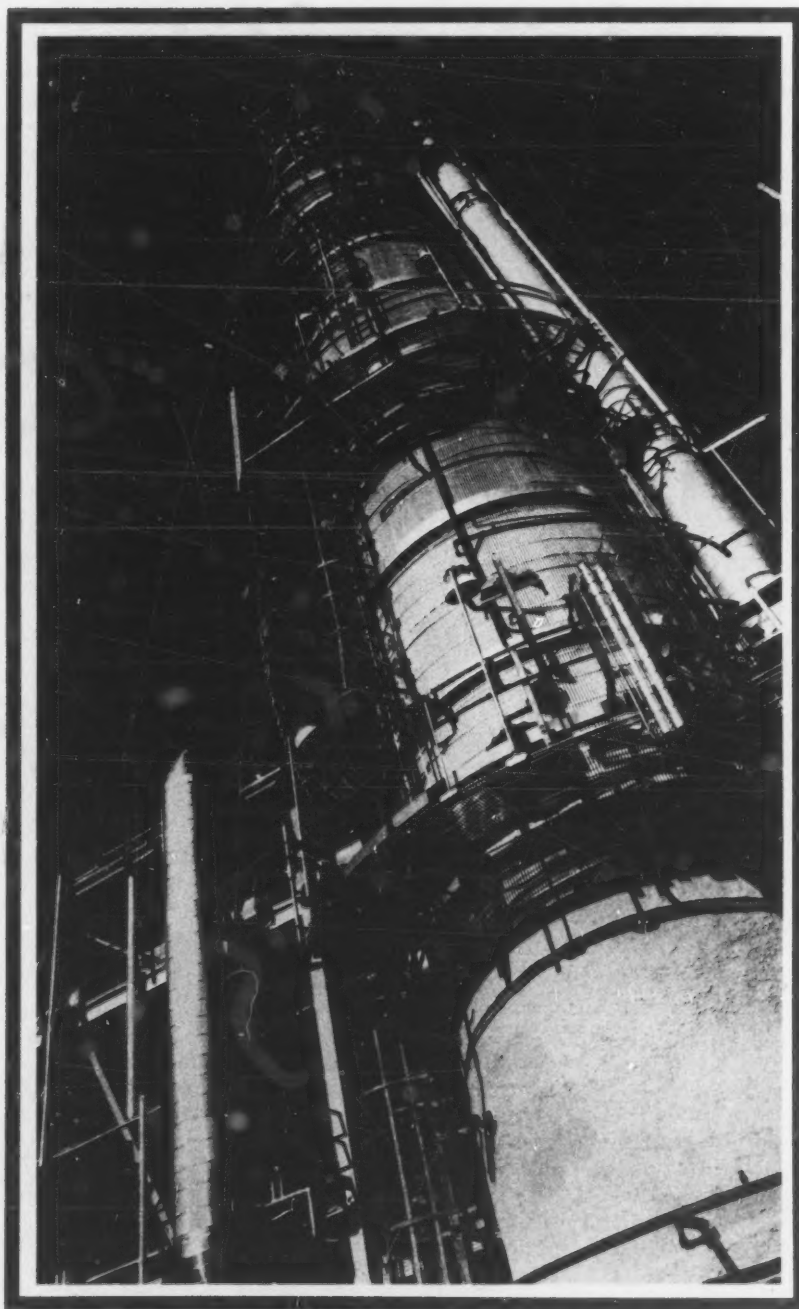
"Toxicity Testing: Strategies to Determine Needs & Priorities" is available from the National Academy Press, 2101 Constitution Ave., N.W., Washington, D.C. 20418 for \$22.50.

Lois Ember, Washington

Hazard not assessable for most of select 65,725 chemicals

	Size of category	PER CENT OF CATEGORY				
		Complete assessment possible	Partial assessment possible	Minimal toxicity data available	Below minimal toxicity data available	No toxicity data available
Pesticides and inert ingredients of formulations	3,350	10%	24%	2%	26%	38%
Cosmetic ingredients	3,410	2	14	10	18	56
Drugs and inert vehicles used in formulations	1,815	18	18	3	36	25
Food additives	8,627	5	14	1	34	46
Chemicals in commerce: ≥ 1 million lb per yr	12,860	0	11	11	0	78
Chemicals in commerce: < 1 million lb per yr	13,911	0	12	12	0	76
Chemicals in commerce: production unknown or inaccessible	21,752	0	10	8	0	82

Natural Gas Liquids Remain Strong Petrochemical Feedstock



Increasing the demand for butane feedstocks is Monsanto's new maleic anhydride plant, the world's largest, in Pensacola, Fla.

Bruce F. Greek, C&EN Houston

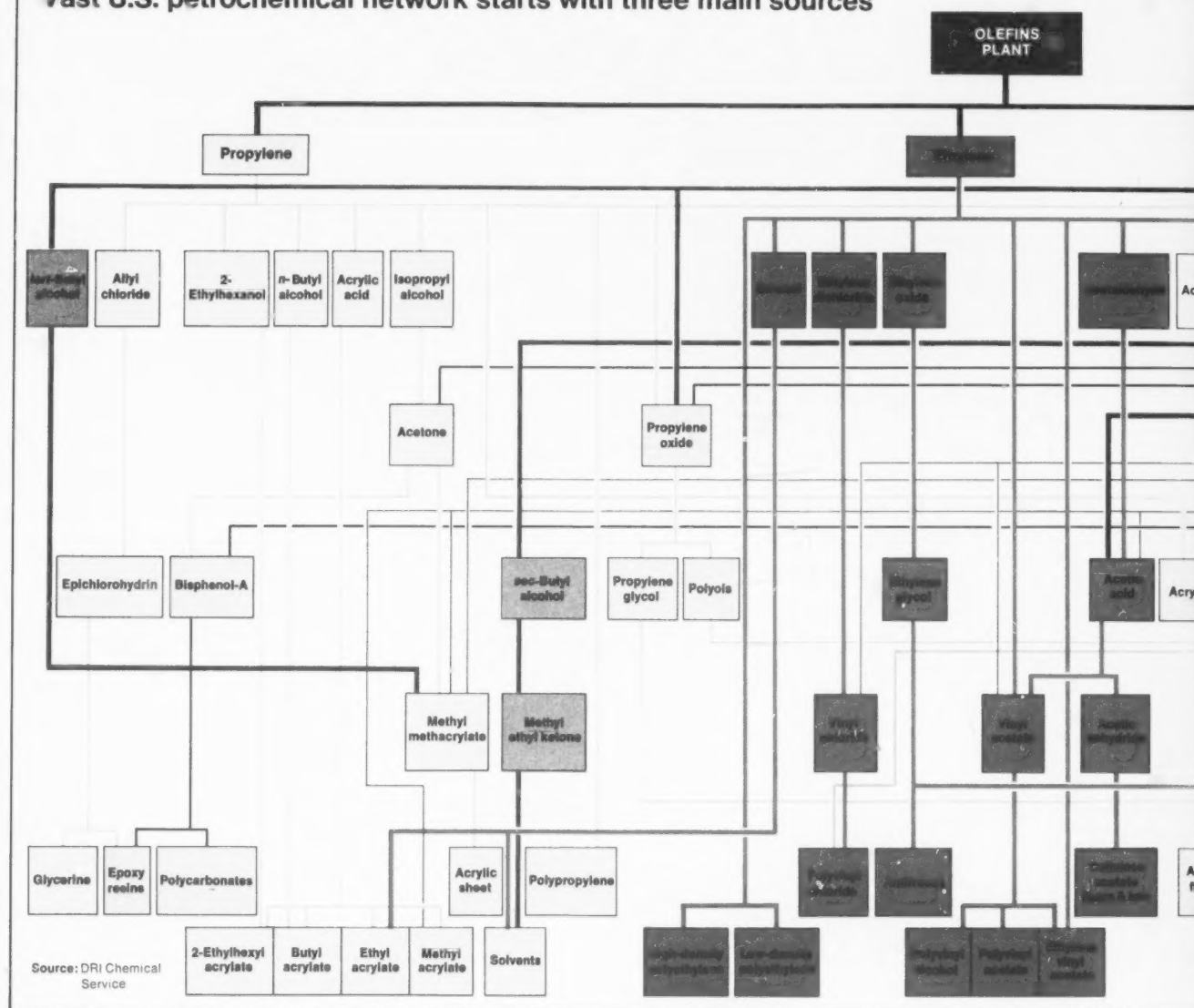
After their most wrenching decade, petrochemicals worldwide have changed in many ways beyond the wildest imagination of the early 1970s. And yet, in other ways, petrochemicals have stubbornly resisted some transformations almost universally predicted.

To size up what has happened to the most basic chemicals of all, and what lies in store, C&EN has visited companies, consultants, and government agencies for this overview. The focus is feedstocks, which have emerged from near obscurity to become by far the dominant cost—and most unpredictable variable—in the petrochemical business.

The ascendancy of raw materials has changed petrochemicals permanently. Growth rates and profitability are much lower now, and international competition has increased greatly. The incredibly complicated web of relationships between feedstocks and other basic hydrocarbons is undergoing computer-aided analysis as never before, and process efficiency is the magic word.

The result for feedstocks in the 1980s is a definite surprise. For the U.S., instead of the wholesale switch widely predicted in the 1970s to oil-based heavy feedstocks, the main trend turned out to be flexibility. Old-fashioned light liquids from natural gas are still highly important in making the dominant olefins as are traditional refinery

Vast U.S. petrochemical network starts with three main sources



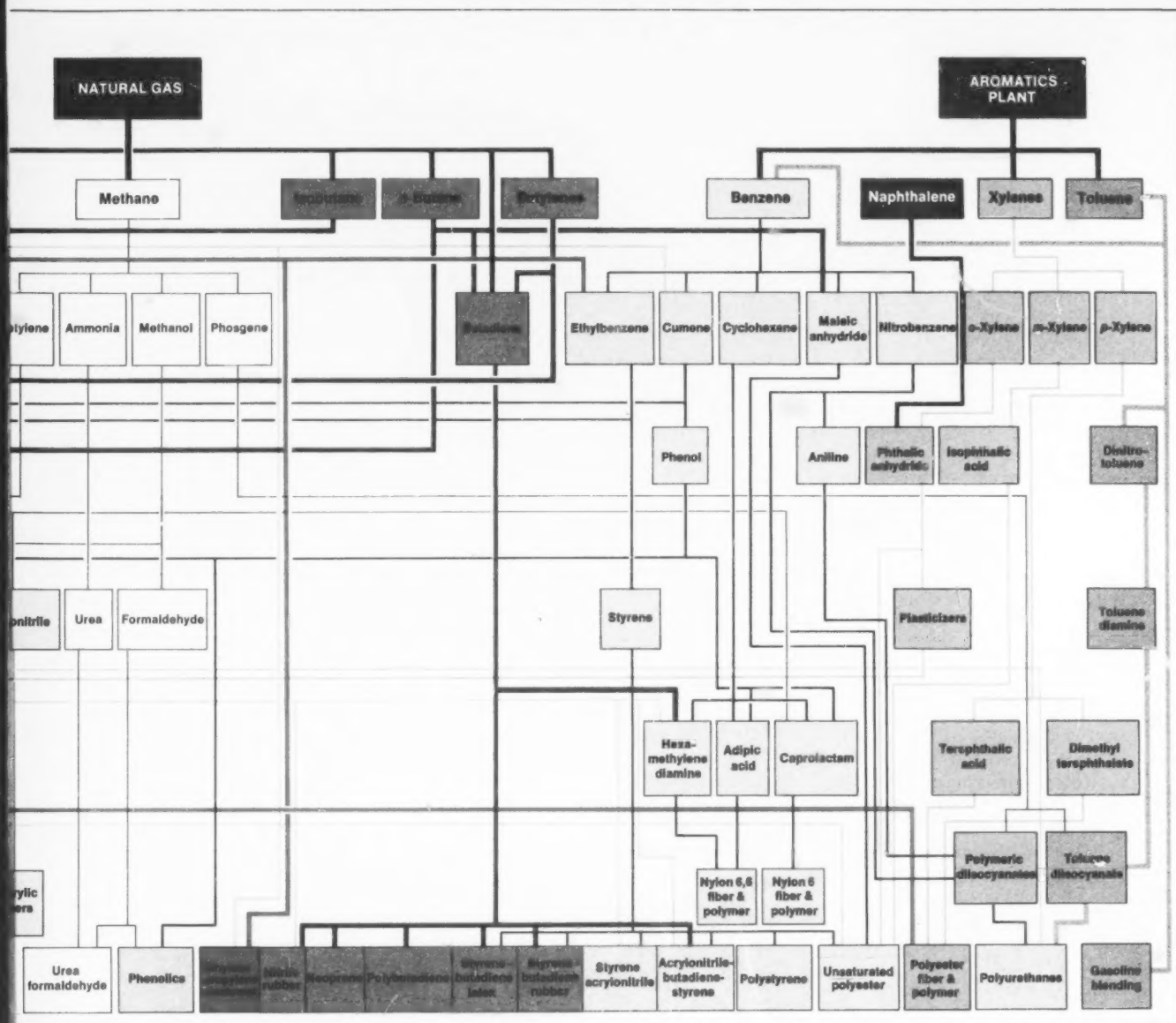
sources in making aromatics. The truly modern petrochemical producer can use practically anything among available feedstocks and may need this flexibility to survive the tangle of influences on choice of feedstock in the rest of the 1980s.

From this point, current thinking is that any change from the present feedstock situation will be gradual. Production growth rates for the rest of this decade are expected to average half or less of those in the 1970s. Hence current worldwide overcapacity will persist much longer than had been forecast.

Demand for petrochemicals in the U.S. is expected to grow more than production, mainly because of a likely decline in net exports of basic petrochemical derivatives as imports surge. For some products, the slump will be steep, for others hardly discernible. And for a fortunate few, a gain in exports could occur. As net exports decline, the U.S. market will have to take up the slack. Even though U.S. demand could grow at a surprising rate, as fabricated plastics capture more markets, the halcyon days of the petrochemical industry are over.

However, the current situation still is far from a struggle for survival. Producers can afford to push hard for all kinds of economies of production and new markets for their products. As might be expected, most attention is going to the biggest and most significant parts of the petrochemical industry— basic olefins and aromatics and their derivative intermediates.

Clearly the most important production route in petrochemicals is steam cracking to make both olefins and aromatics. Steam crackers represent large investments, require



huge quantities of feedstocks, and can make product faster than most sales forces can move them. Steam crackers and their auxiliaries therefore get their full share of corporate attention.

Because of their great rise in economic importance, feedstocks account for a very large part of this attention. Technology comes in for lesser, but still important, efforts.

In the early 1970s, feedstock costs were a tenth or less of what they are today in developed countries. Then, feedstocks accounted for a tenth or at most a fifth of the cost

of making basic petrochemicals. Plant investment represented a major share of production costs. Now the situation is reversed. Feedstocks represent at least half and sometimes nearly 90% of production costs. They represent most of the cash costs of production.

Petrochemical product prices also jumped over the past decade but not so much as feedstock costs. Prices for basic petrochemicals typically have increased six to eight times their early-1970s prices. The smaller increase for products owes mainly to major efforts by producers to

increase process efficiency and shift to feedstocks with higher yields, as well as to reduce various overhead costs. Other price-dampening influences were the lower fraction of costs due to investment and to the much lower profit margins now received by producers. Stiff competition, low capacity use, and customers' price resistance also played a part.

Politics also became a factor. World crude oil prices rose tenfold while U.S. crude oil and natural gas prices remained at controlled prices, at least initially. Later, when U.S.

Petrochemical feedstocks' crucial interplay with fuels

Shadowing petrochemical feedstocks at all times is the enormous U.S. fuels business—gasoline, fuel oil, jet fuel, diesel fuel, and so on. In a myriad of ways, fuels exert a quiet but powerful pull on feedstock prices, frequently sending them up and down independent of petrochemical market forces. It's complex, but it's essential in understanding the ebb and flow of feedstock use.

Fact number one: All hydrocarbons used as petrochemical feedstocks have an alternate use as fuel. This is a basic principle underlying petrochemical economics. It derives from the relatively minor position of petrochemicals as a consumer of crude oil and natural gas—about 7% of the total in recent years.

Fact number two: The alternative fuel value of any hydrocarbon is its lowest value as a petrochemical feedstock. In other words, a hydrocarbon's worth in fuels is a floor value for everything else. Obviously, the fuel value varies enormously with circumstances. An example: Benzene at the moment is inhibited from price increases, despite a big pickup in downstream chemical use, because of weak demand as an octane booster in gasoline. But benzene prices can soar

if the gasoline market gets tight as in 1974 and 1979.

The fuel value of hydrocarbons includes more than just the cost of finding, producing, transporting, and otherwise handling them. Political factors can greatly disturb values. One example is diversion of natural gas supplies from industrial plants to consumer markets in cold weather. Another is crude-oil-producing nations' decisions to sell oil and gas above or below production costs depending on political ideology or need for foreign exchange.

Then there's the weather, not a small influence on feedstocks via fuel markets. For example, as a rule petrochemical producers can expect propane prices to rise in the late summer and early fall as fuel consumers fill their tanks for winter. Then in winter, butane prices often rise as the butane fraction in gasoline is raised to increase volatility for better engine starting. Distillate fuel oils also go through price peaks in cold snaps such as earlier this winter.

Besides this seasonal bobbing, hydrocarbon values can edge up or down slowly over many years under long-run influences. For example, natural gas produced in the U.S. has tended

to become "drier" (contain less ethane and higher hydrocarbons) with time, thereby reducing the potential hydrocarbon supply. As yet, this trend hasn't greatly affected supplies and prices because of developments such as energy conservation and increased percentage recovery of ethane from natural gas. But in another decade, "dry" gas could start its long-predicted squeeze on gas liquids supply.

In the face of all these long- and short-run shifts, a petrochemical producer must pay a slight premium over the net fuel value of the moment to coax hydrocarbons into feedstocks. Example: To obtain propane for a steam cracker, a company must pay more than the heat content value, handling, and other standard cost factors. This is because the propane seller has an investment in facilities to move the propane to fuel markets that must be covered. In addition, the seller expects to remain in business in heating markets—an intangible temporary-sacrifice factor of some value that also must be covered. In other words, the propane buyer must make it worth the seller's while. Similarly, the fuel value of naphtha to an oil company includes the value of retail service stations and the intangible of

oil prices were decontrolled, naphtha and gas oil prices followed the rise in crude, but the light hydrocarbons—natural gas liquids—rose less. Forecast declines in the availability of natural gas liquids became more and more delayed.

As a result, operators of natural gas-based steam crackers built 10 to 20 years earlier had a clear economic advantage. The others, with oil-based plants, had to do something quickly as the 1970s closed with a second round of world crude oil price increases.

Flexibility became the byword. Almost all steam cracker operators in the U.S. boosted plant investment to gain feedstock flexibility. They haven't all shifted to the ultimate slate running from 100% ethane to 100% vacuum gas oil, the heaviest liquid. But producers can use very large quantities of ethane and pro-

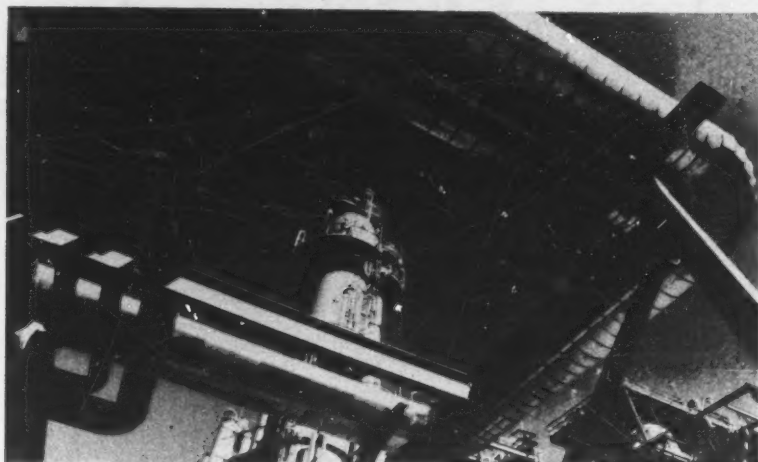
pane when prices favor these light hydrocarbons and can make nearly the same shift to heavy hydrocarbons if economics favor them. In effect, basic petrochemical producers now are set up to use any feedstock, depending on economics, and still meet forecast product demand for most of this decade.

Currently, the feedstock slate for U.S. steam crackers still probably exceeds 65% ethane and propane, down from more than 70% in 1976. After slowly losing feedstock share during the late 1970s, to as little as 60% of the total, ethane and propane topped 75% for most of 1982. The down-shift in the late 1970s occurred as a large number of steam crackers designed for heavier feedstocks came on stream. Since then, economic advantages of ethane and propane over naphtha and gas oil reversed the decline, shutting down

many heavy feedstock crackers for long periods in the early 1980s.

Some 15 billion lb of annual capacity to make ethylene were added from 1975 to 1982, the great majority based on naphtha or gas oil feedstocks. Heavy feedstock-based capacity in 1975 was about 3 billion lb per year. The remainder of capacity in 1975, some 22 billion lb, was based mainly on ethane and propane feedstocks, with a relatively small part based on refineries' off-gas streams from catalytic cracking operations.

These capacity additions in the late 1970s brought total ethylene capacity to about 41 billion lb nameplate. However, actual operating capacity never reached that much. Even before the last plants of that capacity expansion were finished, the cost advantages of ethane and propane became evident.



Exxon's modernized p-xylene unit near its huge Baytown, Tex., refinery

maintaining share of gasoline markets.

These considerations make it eye-crossing to assess the market value of feedstock hydrocarbons. Computers run hard sorting it out. Their programs scoop up the external cost factors and then add the operating conditions of petrochemical plants. Small changes in plant use can have magnified influences on profitability and change what producers can afford to pay for feedstock.

In spite of these complexities—or perhaps because of their intense analysis—it's hard for a petrochemi-

cal producer to gain a large or long-term advantage in feedstock. The refining-petrochemical industries have so many options for feedstock and product slates that advantages or handicaps will be offset sooner or later by other feedstock compositions and product mixes.

As a result, major feedstock shifts tend to happen industrywide rather than by bold individual action. For example, as a result of drawdowns of distillate fuel inventories in cold spells this winter and in anticipation of lower spring demand for heating LPG, prices of ethane and propane have declined sig-

nificantly since year's end and naphtha/gas oil prices (related to fuel oil) have increased. Now most steam cracker operators have shifted toward the lightest practical feedstock composition, pushing up LPG and holding down naphtha/gas oil, especially since these producers have failed to get ethylene price increases.

Note that this feedstock shift was forced from the raw material side, not the market side, of the petrochemical industry. Because of petrochemicals' relatively small size in the world of basic hydrocarbons, petrochemical product demand seldom has as great an influence on feedstock choice as does the dominant influence of raw material values. This can be true even when market conditions seem superficially to tempt a feedstock shift. For example, the shift in recent years to use more ethane and less naphtha/gas oil meant less production of coproduct propylene and butadiene in steam crackers and potentially higher prices for these olefins. However, all that this economic lure actually did was push up butadiene imports and increase recovery of propylene from refinery streams. In other words, the petrochemical world adjusted internally long before it could nudge the elephantine raw material hydrocarbon business, most of it serving fuels.

The hasty shift to greater flexibility then began. Estimates vary, but capacity that can now use ethane and propane probably has risen to about 35 billion lb per year of ethylene. Unless some of the very old capacity based on ethane and propane comes down, the industry probably could meet 90% or more of ethylene demand using these light hydrocarbons for several years to come if demand forecasts are accurate.

Still in the future as another source of light hydrocarbon feedstocks is international trade in propane. (Shipping ethane by means other than pipeline is too expensive, so significant sea transport is unlikely.) Storage and handling facilities are critical cost items in such trade for chemical use. Even more critical is dependability of supply from politically unstable countries.

For these reasons, industry experts believe no plant would be built in the U.S. using imported propane.

Terminals to handle liquefied petroleum gas (LPG), essentially propane and butane, are scattered around the U.S. and various places in Europe, Japan, and other parts of the world. Much of the propane and butane imported to the U.S. comes from Canada and goes mainly to fuel uses. Fuel uses also dominate in other parts of the world. However, potential chemical use in steam crackers is growing in Europe, spurred by the growing availability of gas liquids from the North Sea. European and Japanese terminals are the more likely destinations for ships carrying Middle Eastern and African propane and butane that are U.S. ports.

Just as in the U.S., European feedstock flexibility is growing, mainly

to include ethane and propane in steam crackers designed to use naphtha. Again actual feedstocks used day by day depend on competitive feedstock costs.

Complicating the outlook for internationally transported LPG feedstocks are potential exports of ethylene derivatives from many of the same places, such as Saudi Arabia, that provide natural gas liquids. Because ethane is expensive to ship, most of it produced in the Middle East will be converted there to ethylene derivatives, which are expected to be exported, particularly to Europe. If these derivatives do reach Europe in large quantity at lower than competitive prices, ethylene production in Europe will have to be reduced. This could reduce need for gas liquids, even if they are the lowest-cost feedstock. Steam crackers operating on gas liq-

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*Trademark for saturated aliphatic hydrocarbons essentially free of aromatics.



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Petrochemical Report

Polyolefins continue to grow fastest among olefin uses

	ETHYLENE CONSUMPTION IN END PRODUCTS, BILLIONS OF LB						Total
	Low-density polyethylene	High-density polyethylene	Ethylene oxide	Ethylene dichloride	Ethylbenzene	All other	
1974	6.3	3.0	4.5	3.2	2.0	4.9	23.9
1975	5.1	2.8	4.5	2.4	1.5	4.2	20.5
1976	6.1	3.3	4.3	3.3	2.0	3.4	22.4
1977	6.8	3.8	4.4	3.5	2.2	4.2	24.9
1978	7.5	4.4	4.8	4.0	2.4	4.6	27.7
1979	8.2	5.3	5.4	4.5	2.5	4.1	30.0
1980	7.7	4.7	5.0	3.7	2.1	3.5	26.7
1981	7.6	4.8	4.6	3.8	2.1	4.8	27.7
1982	7.4	5.1	4.7	3.4	1.7	4.2	26.5
1983	8.0	5.9	5.1	3.8	2.0	4.4	29.2
1984	8.1	6.4	5.0	4.0	2.0	4.6	30.1
1985	8.3	6.7	5.0	4.1	2.0	4.9	31.0

	PROPYLENE CONSUMPTION IN END PRODUCTS, BILLIONS OF LB*						Total
	Polypropylene	Acrylonitrile	Propylene oxide	Isopropyl alcohol	Cumene	All other	
1974	2.5	1.8	1.4	1.6	1.2	2.7	11.2
1975	2.1	1.6	1.3	1.3	0.8	2.2	9.3
1976	2.9	1.9	1.5	1.6	1.1	2.5	11.5
1977	3.0	2.1	1.6	1.6	1.1	2.6	12.0
1978	3.5	2.2	1.7	1.6	1.3	2.7	13.0
1979	4.1	2.5	1.9	1.7	1.6	3.3	15.1
1980	3.7	2.3	1.5	1.5	1.3	3.2	13.5
1981	4.2	2.4	1.5	1.3	1.3	4.6	15.3
1982	3.7	2.4	1.3	1.1	1.1	4.0	13.6
1983	4.7	2.5	1.6	1.4	1.3	4.1	15.6
1984	5.0	2.6	1.7	1.6	1.4	4.0	16.3
1985	5.3	2.6	1.8	1.6	1.5	4.4	17.2

* Excludes alkylate (made with isobutane) and other reaction products of propylene used as fuel components. Sources: Chemical Market Associates, C&EN estimates based on U.S. international Trade Commission and Society of Plastics Industry data

uids shipped from the Middle East still will have operating costs higher than those operated in the Middle East because of transportation and handling costs. Presumably, derivatives could be exported to Europe less expensively than those made on site.

Even so, current quantities of propane available for export from Saudi Arabia and other Middle Eastern countries are far below forecasts. The major reason is a big cutback in oil production in Saudia Arabia because of weak markets. Lower oil production reduces associated gas and gas liquids production by the same proportion. Most observers now do not anticipate significant near-term gains in exports of propane and butane from the Middle East. Earlier contracted amounts will be supplied, although most contracts apparently have provisions to al-

low volume reductions as prices rise.

Overall, the trend toward more use of LPG in Europe, Japan, and other regions will come slowly. In the meantime, naphtha and some gas oil will remain the major feedstocks for steam crackers. An expected rise in gasoline demand in Europe could increase the value of naphtha, making chemical producers try to shift to less expensive feedstocks.

The naphtha-gas oil feedstock situation for steam cracking in the U.S. differs. Refinery influences loom large. Here, gasoline volume probably will decline slowly during the 1980s, but octane value will rise. To do this with the low-octane value naphthas produced from the initial distillation of crude oil may require large amounts of aromatics and other octane boosters, divert-

Petrochemicals—a glossary

Aromatics. In common parlance, generally limited to benzene, toluene, and mixed xylenes (plus a small quantity of ethylbenzene). All other aromatics, C_9 and higher, are neglected even though some are sold commercially in small volumes. Naphthalene from coal or petroleum sources is usually considered apart. Aromatics are recovered by extraction from products of catalytic reforming (reformate) in oil refineries, steam-cracking olefins plants (pyrolysis gasoline) and coking of coal (coal tar).

Condensate. A mixture of hydrocarbons, C_5 and higher, produced in natural gas, which are liquid following production from a gas well. The mixture is generally rich in paraffins and low in octane value. Also called "field condensate" or "natural gasoline."

Distillates. Hydrocarbon fractions, largely products of the initial distillation of crude oil, heavier than naphtha up to light lubricating oils. Most are used as fuel products, but some can be feedstocks for steam crackers.

Fuel gas. In petrochemicals, mainly methane and hydrogen produced in cracking processes. Most continues to be burned for energy, but growing needs for hydrogen make separation and purification economically attractive.

Gas oil. A large-sized fraction of crude oil in the boiling range of 400 to 1100 °F. Various adjectival prefixes are used to limit specification of boiling range such as "light" (lower boiling) or "vacuum" (very high boiling). Used as a feedstock in steam- or catalytic-cracking processes; also fractionated to make various fuel products.

Heavy hydrocarbons. Most often C_5 and higher hydrocarbon molecules. "Heavies" in petrochemical and refinery processing include gas oils and naphthas.

Light hydrocarbons. Usually limited to ethane, propane, and butanes. Methane is not included, being considered a separate category.

Liquefied petroleum gas (LPG). Usually limited to propane and butanes in liquid form under pressure at room temperatures. Sometimes includes ethane when mixtures of ethane and propane are used as feedstocks for steam cracking. Major nonchemical use is fuels.

Liquefied refinery gas (LRG). Similar to LPG, but limited to hydrocarbons produced during petroleum refining processes, mainly crude oil distillation.

Naphtha. A petroleum fraction boiling in the range of 100 to 400 °F. Various adjectival prefixes are used to limit specification of boiling range such as "light" or "heavy" depending on use; or "straight run" or "virgin" indicating that source was initial distillation of crude oil. Used as a gasoline component and as a feedstock for processes such as steam cracking; often used alternatively with gas oil, depending on current economics.

Natural gas. Gaseous streams from wells drilled to produce crude oil or natural gas itself. Consists of methane, ethane, propane, butanes, and small amounts of heavier hydrocarbons as well as widely varying amounts of carbon dioxide, hydrogen sulfide, nitrogen, water, and other volatile materials. Usually processed near production sites to remove all materials except methane and some ethane. Sold on basis of either volume or heating value.

Natural gasoline. Hydrocarbons condensed during production of natural gas. Often, propane and butanes are removed, and remaining material is used as a component of motor gasoline or fed to steam crackers.

Natural gas liquids (NGL). Ethane, propane, and higher hydrocarbons found with methane in natural gas. This term frequently used interchangeably with LPG and sometimes with light hydrocarbons.

Octane pool. The average antiknock value of all the hydrocarbon components a petroleum refiner or blender has available for making gasoline. The monetary value of these components is based on both selling price and their replacement value in making a gasoline of a given octane. This value determines cost petrochemical buyers must pay to remove a given hydrocarbon from a refinery stream for use as a chemical feedstock.

Pyrolysis gasoline. A product stream from steam-cracking olefins plants. Contains a high proportion of aromatics (benzene, toluene, xylenes). Used as a source of individual aromatics or as an octane enhancer for motor gasoline.

Raffinate. Hydrocarbon fraction remaining after solvent extraction of aromatic products from catalytic reforming (reformate) and/or pyrolysis gasoline. Raffinate usually has low octane value and is highly paraffinic, making it useful as a feedstock for steam cracking.

Reformate. Product from catalytic reforming in refineries of hydrocarbon streams high in nonaromatic cyclic compounds. Value depends strongly on octane value of contained aromatics. The source, via solvent extraction technology, of most common aromatics produced in refineries.

Steam cracking. Process of breaking down hydrocarbons in olefins plants at high temperatures in the presence of steam. Precise control of operating conditions required to produce optimum slate of products.

ing them from potential use in chemicals.

Another refinery problem in the making concerns the raffinate left after the aromatics fraction is extracted from reformate. This material has been depleted in aromatics and potentially aromatic hydrocarbons, leaving a highly paraffinic mixture of hydrocarbons, whose re-

sponse to lead alkyls is relatively poor.

This raffinate could find use in steam crackers as a new feedstock if its price were reduced and if prices of propylene and other coproducts from steam cracking naphtha improved. Raffinate, a material with physical properties similar to naphtha, seems to be waiting in the

wings for its chance in making chemicals.

Gas oil, as well as lighter refinery fractions, could become more important as a steam cracker feedstock in 1985 and later. Two cost factors in the world oil and gas industry are behind this potential development. One already has happened—a significant reduction in prices for

Prices for basic petrochemicals have settled since 1981 in line with feedstock costs

Cents per gal, midyear	Crude oil ^a	Ethane	Propane	Butane	No. 2 fuel oil ^b	Cents per lb, annual average	Ethylene	Propylene	Butadiene	Benzene ^a	p-Xylene
1973	\$ 5.30	3.0¢	9.5¢	7.0¢	11.8¢	1973	3.3¢	3.2¢	8.1¢	3.94¢	6.5¢
1974	9.10	5.9	16.0	18.2	23.0	1974	7.5	5.5	14.6	8.83	14.7
1975	10.40	9.2	18.0	19.0	26.2	1975	8.8	7.0	16.5	9.50	14.0
1976	10.90	10.4	19.5	32.0	28.5	1976	11.2	8.4	17.6	10.5	15.7
1977	12.00	13.9	24.5	25.8	32.4	1977	12.0	9.5	17.8	10.3	14.7
1978	12.50	14.2	23.5	24.3	33.7	1978	12.5	9.7	19.4	10.0	12.4
1979	17.70	17.5	27.5	48.6	48.5	1979	13.8	10.5	22.0	17.9	22.2
1980	28.10	28.0	42.0	54.0	71.9	1980	21.7	20.2	27.0	21.7	26.0
1981	35.20	31.3	47.0	56.4	89.4	1981	24.9	23.8	34.0	23.4	31.0
1982	31.90	22.0	36.5	63.2	85.5	1982	19.8	21.0	35.0	20.6	28.0
1983	29.00	28.1	42.0	72	75	1983	20.6	20.0	29.0	20.4	25.0
1984	28.80	30	48	75	75	1984	20.5	19.5	30.0	20.4	27.0

^a Dollar per barrel; reflects combination of average of domestic two-tier pricing (when applicable) and average price of imported crude oils. ^b Roughly equivalent to commercial value of naphtha/gas oil fractions. Sources: Department of Energy, C&EN estimates

^a To convert to common unit of dollars per gallon, multiply by 7.365. Sources: U.S. International Trade Commission, C&EN estimates

crude oil. Typically, crude oil prices fell \$4.00 to \$5.00 per barrel, or from around \$34 a bbl to \$29 a bbl over the past 18 months. Most analysts no longer forecast continuing large increases in crude prices. (All of them naturally temper forecasts with the assumption that no Middle East war or other crisis will take out a major part of oil supply.) A decline in crude prices makes the heavier hydrocarbon fractions from refineries less expensive as steam cracker feedstocks.

The other cost factor, gas liquids prices, is much less clear. This depends on whether U.S. government controls on natural gas are allowed to expire in 1985. Controls tend to hold down prices of gas liquids by adding incentive to remove them from the gas for additional income. Partial decontrol of gas prices also ranks as a good possibility, making

estimates of feedstock costs a bit more complex. If gas prices were completely and abruptly decontrolled, an upward ripple in costs might develop along with some sudden shifts in chemical feedstocks.

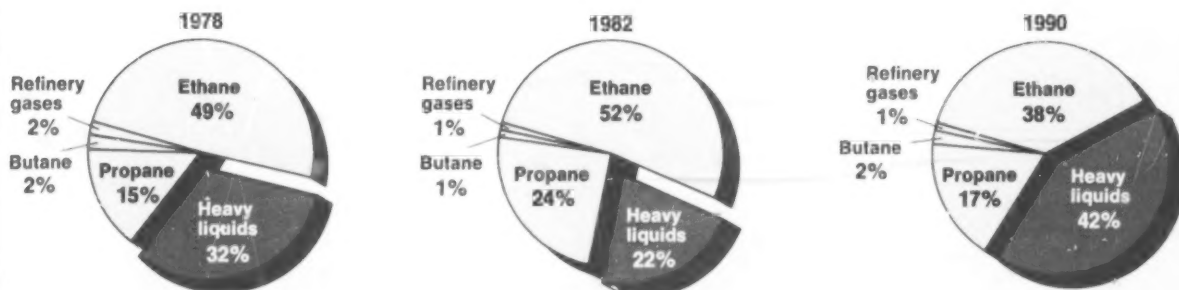
However, barring such an extreme move, many steam cracker operators, especially those in special market situations for ethylene derivatives, will prefer ethane and propane feedstock for a long time to come. So the amount of ethylene produced from ethane and propane probably will not decline very much over the next five years. Still, growth in ethylene supplies will come largely from heavier feedstocks, leading to a decline in the fraction from gas liquids.

The question arises of whether another steam cracker fed ethane-propane mixtures will ever be built in the U.S. In the past, analysts have

said time and again that "the last ethane-propane cracker has been built"—only to eat their words later. They have said it again about the 1980s, but the possibility of another distinctly exists. Current thinking holds that one will be built but probably not before 1990 unless a field of unexpectedly wet gas (high in liquids) goes into production. If such a steam cracker is built, it probably will have some flexibility to handle heavy hydrocarbons. This would mean a very high capital cost, and a consortium of owners probably would have to be formed to finance the project.

Regardless of whether such a cracker is built, more capacity will be needed toward the end of the 1980s, industry analysts say, despite low average petrochemical growth rates for the rest of the decade. Some earlier shut-down steam cracking ca-

Heavy liquids feedstock use for olefins may expand again after recent 1982 low point



Sources: DeWitt & Co., C&EN estimates

capacity based on heavy hydrocarbons is being brought back on stream. And, debottlenecking can add 3 to 5% to capacity over the next two years. When all these additions are noted and scrapped capacity taken off the list, nameplate capacity after 1985 will total 37 billion to 38 billion lb a year of ethylene. If demand reaches 31 billion lb in 1985, the operating rate then will be 85% or higher. So beyond 1985, additional demand growth could require new capacity.

Meanwhile, demand for other basic petrochemicals also will be growing. The rate for some could be higher than for ethylene. Such demand can't be met from the gas liquids crackers very well, especially for aromatics. This points to a need for more use of crackers fed heavy hydrocarbons unless the needed coproducts can be obtained from sources other than U.S. steam crackers, such as refineries or foreign plants.

New short-residence-time furnaces up ethylene yields

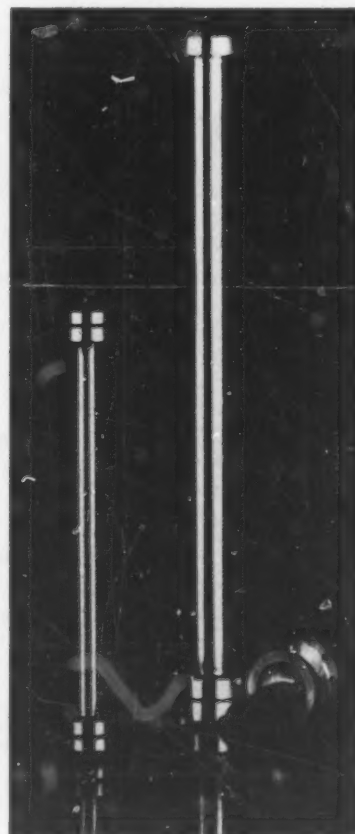
Product	% yield from steam cracking light gas oil	
	Conventional furnace	Millisecond furnace
Hydrogen & methane	10.6%	9.7%
Acetylene	0.3	0.5
Ethylene	24.4	27.0
Ethane	3.1	2.6
Propyne	0.5	0.9
Propylene	14.1	13.8
Propane	0.5	0.6
C ₄ s	10.7	11.8
C ₅ s (to 390 °F)	15.5	15.9
Fuel oil	20.3	17.2
TOTAL	100.0%	100.0%

Source: M. W. Kellogg Co.

Propylene can be obtained from catalytic cracking units at refineries, but only if purification facilities are available. Butadiene can be made in butylene or butane dehydrogenation plants, although these aren't

operating at present because of a wave of imports. Plenty of aromatics are available in refinery reformate, but, as already mentioned, rising gasoline octane requirements can increase the cost of luring aromatics from the gasoline pool for use in chemical intermediates. The net result analysts see from all these influences is that economics will favor more use of heavy feedstocks in steam crackers to give the additional ethylene and coproducts.

A shift in cracker technology such as installing feedstock flexibility also can increase ethylene production. Another technological modification receiving much attention worldwide is increasing ethylene yield at the expense of lower-valued fuel oils and fuel gases. Generally, this technology involves shortening the feedstocks' residence time in the furnaces and raising the temperature. Current residence times at the most advanced new furnaces range below 0.1 second in contrast with up



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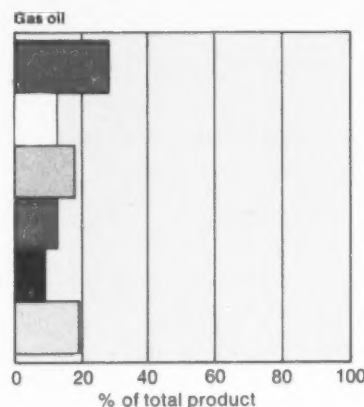
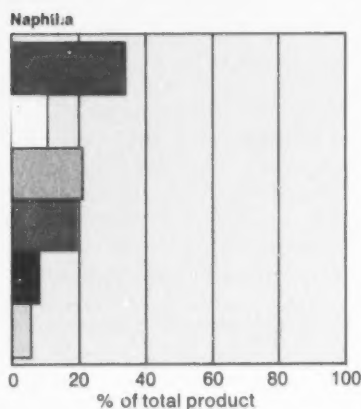
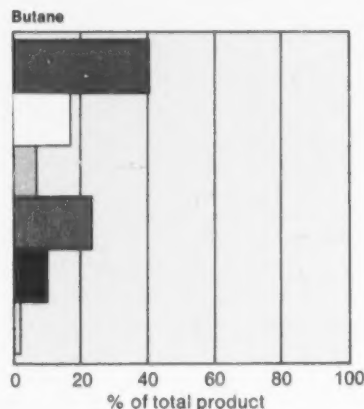
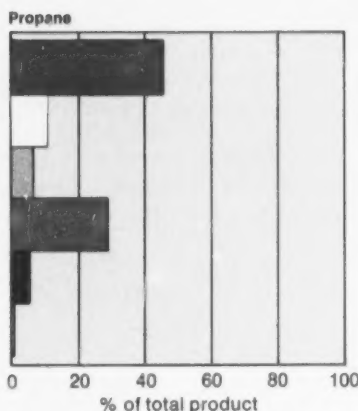
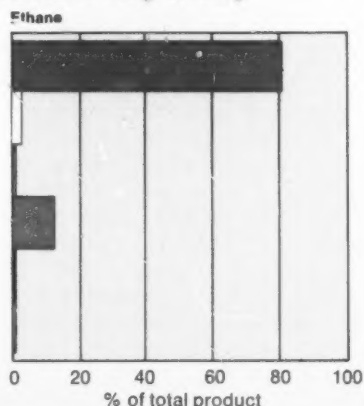
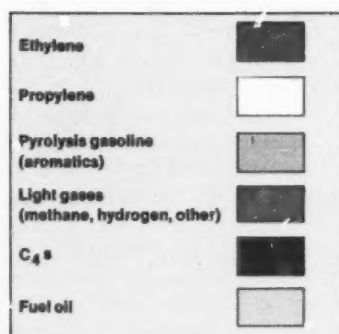
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Yields of feedstocks in steam crackers vary widely



Sources: Industry, C&EN estimates

to a full second in older gas liquids crackers. Obviously, shorter residence time can be an energy saver.

Cost gains from such technology jumps can cascade at integrated producers lowering costs at all stages, from feedstock to petrochemical to intermediate to polymer. So producers with a true cost advantage are those with low costs for the whole product chain. In this time of ration-

alization or restructuring in the petrochemical industry, surviving firms will be those with the better positions for all costs—raw material, manufacturing, and marketing.

Saving energy has been another technology crusade. Since 1972, the chemical industry has reduced its consumption of energy per unit of production about 25%. This has changed the fuel-to-feedstock ratio

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significantly. In 1972, on average, 1.5 bbl of fuel was used for every barrel of feedstock processed. By 1980, conservation measures had reduced that ratio to about 1.1. Analysts forecast that the ratio will reach 1.0 by 1985 and 0.9 by 1990. The drive will continue because of further expected increases in U.S. energy and feedstock costs. In 1980, with U.S. crude oil still under price control, U.S. chemical producers had an international cost advantage of about \$8.00 per bbl. When crude oil was decontrolled, the advantage declined to about \$6.00 in constant dollars. If natural gas is decontrolled beginning in 1985, the advantage for oil is forecast to drop to \$4.00 per bbl.

This kind of energy conservation allied with improved yields from feedstocks could keep the U.S. basic petrochemical industry above the survival stage in its fierce new international competition. Refinements of new technology and operating strategies will further help im-

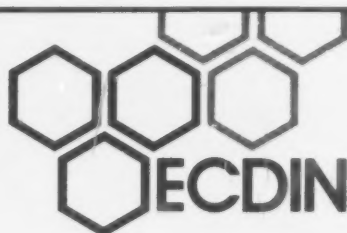
prove efficiencies and in turn profitability.

U.S., European, and Japanese petrochemical producers probably will never have feedstock and fuel costs as low as those in areas, such as the Middle East, where new petrochemical production has begun. The very competition, however, will keep efforts going to improve efficiencies through all kinds of process innovation. Some markets supplied by existing petrochemical plants will be lost to newer producers in the Middle East, Canada, Mexico, and Asia. These lost markets, however, are being supplied at present by the least efficient plants. Such plants are the logical candidates for shutdown, which will lead to a worldwide efficiency gain.

For the moment, this shakeout is proceeding slowly—too slowly to affect very much the dominant feedstock trends. For Europe and Japan, oil-based liquids are still entrenched. For newer petrochemical producing

regions, especially in developing countries, gas liquids are the rule for olefins and refinery streams for aromatics. For the U.S., gas liquids have fooled the experts and are still number one for steam cracking, with refinery streams the main source of aromatics and a strong backup in propylene.

Despite the continuity of gas liquids in the U.S. as petrochemical feedstocks, producers have drastically changed their feedstock stance in the upheavals of the past 10 years. Switchability is the new way of life for producers with long-run survival hopes, and most have spent the money to arrange it. They are not so vulnerable to a sudden feedstock cost shift as they were a decade ago. And they have given petrochemical technology a renewed push to lower process costs and improve yields in the face of a determined market drive from new petrochemical producing regions with vast supplies of low-cost gas liquids. □



Environmental Chemicals Data and Information Network

- A handbook on-line available from

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- The databank - developed at the *Ispra Establishment of the Commission of the European Communities Joint Research Centre* - is a tool for Environmental Managers, Occupational Safety, Governmental Decision Makers, Industry, and Research Bodies
- ECDIN includes data on
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 - Odour and Taste Threshold Concentrations
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